EFFECT OF PROCESSED SPENT BLEACHING EARTH AND KENAF FIBER TOWARDS HEAT OF HYDRATION AND STRENGTH OF FOAMED CONCRETE

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Bahan-bahan pozzolanik seperti Processed Spent Bleaching Earth (PSBE) telah digunakan secara meluas sebagai bahan pengganti simen separa dalam pembinaan konkrit kerana sifat pozzolannya. PSBE adalah sisa pepejal yang dihasilkan daripada proses pelunturan dalam industri minyak sawit dengan menggunakan pengekstrakan pelarut minyak mentah. Dalam kajian ini, kesan PSBE dan serat kenaf pada kebolehkerjaan, haba penghidratan dan kekuatan mampatan konkrit berbuih telah disiasat. Ini adalah tiga campuran yang telah disediakan iaitu konkrit berbuih (FC), 30% PSBE (PFC) dan 30% PSBE + serat kenaf (PKC). Semua campuran telah diuji dengan ujian kebolehkerjaan terlebih dahulu. Dari eksperimen ini, didapati PKC mempunyai aliran aliran terendah, iaitu sekitar 8% lebih rendah berbanding dengan FC. Untuk haba ujian penghidratan, keputusan telah membuktikan bahawa PKC menghasilkan konkrit berbuih yang mempunyai suhu puncak terendah, iaitu 7% dan 25% lebih rendah daripada FC untuk 150x150x150mm dan 300x300x300mm saiz kubus. Selain itu, diperhatikan bahawa PKC menggunakan masa terpanjang untuk mencapai suhu puncaknya berbanding dengan FC sebanyak 30% dan 45% lebih lama untuk saiz kiub 150x150x150mm dan 300x300x300mm. Akhir sekali, bagi ujian mampatan, ia menunjukkan bahawa PFC mempunyai kekuatan mampatan tertinggi selama 7, 28 dan 60 hari berbanding yang lain. Ringkasnya, berdasarkan pemerhatian dan keputusan yang diperolehi oleh kajian ini, dapat disimpulkan bahawa kehadiran PSBE yang bertindak sebagai pengganti simen separa adalah bermanfaat, terutamanya untuk pengeluaran konkrit berbuih.

ABSTRACT

Pozzolanic materials such as Processed Spent Bleaching Earth (PSBE) have been widely used as a partial cement replacement material in concrete construction due to its pozzolanic properties. PSBE is solid waste generated from the bleaching process in the palm oil industry by using solvent extraction of crude oil. In this study, the effects of PSBE and kenaf fiber on workability, the heat of hydration and compressive strength of foamed concrete investigated. These are three mixtures that have prepared, namely foamed concrete (FC), 30% PSBE (PFC) and 30% PSBE + kenaf fiber (PKC). All the mixtures have been tested with the workability test first. From the experiment, it found that PKC has the lowest flowability, which is about 8% lower compared with FC. For the heat of hydration test, the results have proved that PKC produced foamed concrete that has the lowest peak temperature, which is 7% and 25% lower than FC for 150x150x150mm and 300x300x300mm cube sizes. Other than that, it observed that PKC consumed the longest time taken to achieve its peak temperature compared with FC by 30% and 45% longer for 150x150x150mm and 300x300x300mm cube sizes. Lastly, for the compression test, it shown that PFC has the highest compressive strength for 7, 28 and 60 days compared to others. In a nutshell, based on observations and results obtained by this study, it can be concluded that the presence of PSBE that act as partial cement replacement is a beneficial, especially for the production of foamed concrete.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	Percentage
g	Gram
^0C	Degree Celcius
kg/m^3	Kilogram Per Meter Cube
MPa	Mega Pascal
L	Litre
m^3	Meter cube
kg	Kilogram

LIST OF ABBREVIATIONS

Sdn. Bhd.	Sendirian Berhad
SBE	Spent Bleaching Earth
PSBE	Processed Spent Bleaching Earth
OPC	Ordinary Portland Cement
ASTM	American Society for Testing and Materials
BS	British Standard
FC	Foamed Concrete
PFC	Foamed Concrete with PSBE
PKC	Foamed Concrete with PSBE and Kenaf Fibre
w/c	Water per cement
UMP	University Malaysia Pahang
CO_2	Carbon Dioxide
C_3S	Tricalcium Silicate
C_2S	Dicalcium Silicate
C_3A	Tricalcium Aluminate
C_4AH	Calcium Aluminate Hydrate
SiO_2	Silicon Dioxide
$CaCO_3$	Calcium Carbonate
$Ca(OH)_2$	Calcium Hydroxide
C-S-H	Calcium Silicate Hydrate
H_2O	Water
Al_2O_3	Aluminium Oxide
kg/m^3	Kilogram per meter cube
MPa	Mega Pascal
L	Litre
m^3	Meter cube
kg	Kilogram

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, foamed concrete commonly used for the construction of large lightweight component such as beams and partitions rather than using the normal concrete because of its advantages. Foamed concrete consists of random air voids caused by the air bubbles created from the mixture of foaming agents in a mortar (Amran, Farzadnia, & Ali, 2015). The foaming agent used during the mixing process of foamed concrete must produce air bubbles that can withstand with a high level of stability and can resists to the physical and chemical from the mixing, placing and hardening process of foamed concrete.

Foamed concrete has unique properties such as low density which can help to reduce the structural dead loads. Furthermore, the low density of this concrete can reduce the labour cost as only a small amount of workers needed to manage and handle the construction. In addition, the transportation cost can be saved too. The lightweight properties of foamed concrete make the transportation cost of precast structure from the factory to the construction site cheaper because only smaller lorries or trailers needed to transport them compared with the structure made up of normal concrete. Besides, it enhances the fire resistance, thermal conductivity and sound absorbance due to its textural surface and microstructural cells. Other than that, foamed concrete also have high flowability, which they can compact themselves significantly, and reduce the dependency towards the usage of the vibrator.

Thus, this study will describe the results of a laboratory-based finding on temperature profiles that may arise in foamed concrete due to hydration of cement and their effect towards the cube strength. The use of processed spent bleaching earth also was investigated to reduce the temperature rises. Furthermore, this study will consider whether the temperature profiles and strengths can be estimated.

1.2 Problem of Statement

The more excessive construction that uses normal concrete rather than foamed concrete will lead the cutting of landfills activities happened continuously to produce the aggregates. Cutting of landfills will cause the destruction of the environment and disturbance towards the wildlife and aquatic ecosystem. Besides, cutting of landfills also may lead greenhouse effect to occur at the surrounding area where the development took place as trees and landfills will be cut down to get the construction materials from under the ground, which is the aggregates. The ecosystems of aquatic life also will be disrupted and the water quality at the river located near to the construction area become worse because of the flow of muddy water from the cut of landfills area will flow into the river.

Other than that, the cost of production of normal concrete is more expensive compared with foamed concrete. This happened because the production of normal concrete required aggregates, which not necessary for the production of foamed concrete. The labour cost to produce the normal concrete also higher than the labour cost for the production of foamed concrete as more workers needed to construct the structure using normal concrete because of high-density behaviour. Finally, high density of normal concrete cause the cost of the transportation for normal concrete is more expensive than the foamed concrete too as the precast structure made up by using normal concrete required larger size of transportation in order to be transported from the factory to the construction site compared with the structure made up of foamed concrete (Amran et al., 2015).

Besides, the production of concrete will produce carbon dioxide (CO_2) gaseous. The CO_2 produced due to the chemical effect that took place when the cement added with the water during the mixing and curing process. The CO_2 released towards the atmosphere. Abundant CO_2 will cause greenhouse effect happened. The more the construction occurs, the more the CO_2 gaseous released.

Lastly, cracking of concrete usually occurred at large structures due to some factors such as heat of hydration. The heat of hydration can be defined as a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. The larger the surface of a structure, the higher the heat of hydration. This is why cracking usually occur at large massive structure.

1.3 Objectives

The objectives of this study are:

i. To identify the flow values due to the presence of kenaf and processed spent bleaching earth (PSBE) on foamed concrete workability.
ii. To determine the effect of kenaf and processed spent bleaching earth (PSBE) on foamed concrete compressive strength.
iii. To determine the effect of kenaf and processed spent bleaching earth (PSBE) on the hydration of foamed concrete.

1.4 Scope of Research

This research was done to determine the workability of fresh, foamed concrete. Other than that, this research also was carried out to determine the compressive strength and heat of hydration of foamed concrete too. The workability test was carried out first before the concrete poured into the moulds according to ASTM C230/C230M Standard – Standard Specification for Flow Table for Use in Tests of Hydraulic Cement. The cube beams with a dimension of 150mm x 150mm x 150mm and 300mm x 300mm x 300mm were used for the heat of hydration test as followed to ASTM C186-17 – Standard Test Method for Heat of Hydration of Hydraulic Cement. Besides, the cube beams with a dimension of 150mm x 150mm x 150mm were used for compressive strength test as referred to ASTM C109 Standard-Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.

REFERENCES

Abbas, Z. H., & Majdi, H. S. (2017). Study of heat of hydration of Portland cement used in Iraq. *Case Studies in Construction Materials*, *7*(April), 154–162. https://doi.org/10.1016/j.cscm.2017.07.003

Amran, Y. H. M., Farzadnia, N., & Ali, A. A. A. (2015). Properties and applications of foamed concrete ; a review. *CONSTRUCTION & BUILDING MATERIALS*, *101*, 990–1005. https://doi.org/10.1016/j.conbuildmat.2015.10.112

Cook, M. D., Ley, M. T., & Ghaeezadah, A. (2014). A workability test for slip formed concrete pavements. *Construction and Building Materials*, *68*, 376–383. https://doi.org/10.1016/j.conbuildmat.2014.06.087

Falliano, D., De Domenico, D., Ricciardi, G., & Gugliandolo, E. (2019). Compressive and flexural strength of fiber-reinforced foamed concrete: Effect of fiber content, curing conditions and dry density. *Construction and Building Materials*, *198*, 479–493. https://doi.org/10.1016/j.conbuildmat.2018.11.197

Falliano, D., Domenico, D. De, Ricciardi, G., & Gugliandolo, E. (2018). Experimental investigation on the compressive strength of foamed concrete : Effect of curing conditions , cement type , foaming agent and dry density. *Construction and Building Materials*, *165*, 735–749. https://doi.org/10.1016/j.conbuildmat.2017.12.241

Fathilah, N. N. F. M. & Tan, C. S. (n.d.). *Flexural Strength of Lightweight Foamed Concrete using cement to sand ratio 3 : 1 with Inclusion of Polypropylene Fibre*. 270–279.

Harith, I. K. (2018). Case Studies in Construction Materials Study on polyurethane foamed concrete for use in structural applications. *Case Studies in Construction Materials*, *8*(November 2017), 79–86. https://doi.org/10.1016/j.cscm.2017.11.005

Hilal, A. A., Thom, N. H., & Dawson, A. R. (2015). On entrained pore size distribution of foamed concrete. *Construction and Building Materials*, *75*, 227–233. https://doi.org/10.1016/j.conbuildmat.2014.09.117

Jitchaiyaphum, K., Sinsiri, T., & Chindaprasirt, P. (2011). Cellular lightweight concrete containing pozzolan materials. *Procedia Engineering*, *14*, 1157–1164. https://doi.org/10.1016/j.proeng.2011.07.145

Jones, M. R., & Mccarthy, A. (2006). *Heat of hydration in foamed concrete : Effect of mix constituents and plastic density*. *36*, 1032–1041. https://doi.org/10.1016/j.cemconres.2006.01.011

Kaur, P., & Talwar, M. (2017). Different types of Fibres used in FRC. *International Journal of Advanced Research in Computer Science*, *8*(4), 2015–2018. Retrieved from https://www.ijarcs.info/index.php/Ijarcs/article/viewFile/3782/3263

Khan, R., Hassan, M. S., Jang, L. W., Yun, J. H., Ahn, H. K., Khil, M. S., & Lee, I. H. (2014). Low-temperature synthesis of ZnO quantum dots for photocatalytic degradation of methyl orange dye under UV irradiation. *Ceramics International*, *40*(9 PART B), 14827–14831. https://doi.org/10.1016/j.ceramint.2014.06.076

Kupaei, R. H., Alengaram, U. J., Jumaat, M. Z. Bin, & Nikraz, H. (2013). Mix design for fly ash based oil palm shell geopolymer lightweight concrete. *Construction and Building Materials*, *43*, 490–496. https://doi.org/10.1016/j.conbuildmat.2013.02.071

Kuzielová, E., Pach, L., & Palou, M. (2016). *Effect of activated foaming agent on the foam concrete properties*. *125*, 998–1004. https://doi.org/10.1016/j.conbuildmat.2016.08.122

Lim, S. K., Tan, C. S., Lim, O. Y., & Lee, Y. L. (2013). Fresh and hardened properties of lightweight foamed concrete with palm oil fuel ash as filler. *Construction and Building Materials*, *46*, 39–47. https://doi.org/10.1016/j.conbuildmat.2013.04.015

Loh, S. K., James, S., Ngatiman, M., Cheong, K. Y., Choo, Y. M., & Lim, W. S. (2013). Enhancement of palm oil refinery waste - Spent bleaching earth (SBE) into bio organic fertilizer and their effects on crop biomass growth. *Industrial Crops and Products*, *49*, 775–781. https://doi.org/10.1016/j.indcrop.2013.06.016

Lu, Y., Shi, G., Liu, Y., Ding, Z., Pan, J., Qin, D., … Shao, H. (2018). Study on the effect of chloride ion on the early age hydration process of concrete by a non-contact monitoring method. *Construction and Building Materials*, *172*, 499–508. https://doi.org/10.1016/j.conbuildmat.2018.03.206

Ma, C., & Chen, B. (2016). Properties of foamed concrete containing water repellents. *Construction and Building Materials*, *123*, 106–114. https://doi.org/10.1016/j.conbuildmat.2016.06.148

Mana, M., Ouali, M. S., de Menorval, L. C., Zajac, J. J., & Charnay, C. (2011). Regeneration of spent bleaching earth by treatment with cethyltrimethylammonium bromide for application in elimination of acid dye. *Chemical Engineering Journal*, *174*(1), 275–280. https://doi.org/10.1016/j.cej.2011.09.026

Munir, A., Abdullah, Huzaim, Sofyan, Irfandi, & Safwan. (2015). Utilization of palm oil fuel ash (POFA) in producing lightweight foamed concrete for non-structural building material. *Procedia Engineering*, *125*, 739–746. https://doi.org/10.1016/j.proeng.2015.11.119

Nambiar, E. K. K., & Ramamurthy, K. (2007). Air-void characterisation of foam concrete. *Cement and Concrete Research*, *37*(2), 221–230. https://doi.org/10.1016/j.cemconres.2006.10.009

Ngo, S.H.; Le, T.T.T.; Huynh, T. P. (2017). Effect of fly ash content on the compressive strength development of concrete. *Tạp Chí KHCN Xây Dựng*, *2*(2003), 31–36.

Odler, I., & Dörr, H. (1979). A reply to T. Knudsen’s discussion of the paper “early hydration of tricalcium silicate. I. Kinetics of the hydration process and the stoichiometry of the hydration products.” *Cement and Concrete Research*, *9*(6), 801. https://doi.org/10.1016/0008-8846(79)90078-4

Ogah, O. (2016). Effect of Curing Methods on the Compressive Strength of Concrete. *International Journal Of Engineering And Computer Science*, 1–9. https://doi.org/10.18535/ijecs/v5i7.09

Rokiah, O., Khairunisa, M., Youventharan, D., & Arif, S. M. (2019). Influence of processed spent bleaching earth on the durability of foamed concrete in acidic environment. *IOP Conference Series: Earth and Environmental Science*, *244*, 012024. https://doi.org/10.1088/1755-1315/244/1/012024

Senff, L., Barbetta, P. A., Repette, W. L., Hotza, D., Paiva, H., Ferreira, V. M., & Labrincha, J. A. (2009). Mortar composition defined according to rheometer and flow table tests using factorial designed experiments. *Construction and Building Materials*, *23*(10), 3107–3111. https://doi.org/10.1016/j.conbuildmat.2009.06.028

Tanveer, A., Jagdeesh, K., & Ahmed, F. (2017). *Foam Concrete*. *8*(1), 1–14.

Wang, C., Hao, P., Ruan, F., Zhang, X., & Adhikari, S. (2013). Determination of the production temperature of warm mix asphalt by workability test. *Construction and Building Materials*, *48*, 1165–1170. https://doi.org/10.1016/j.conbuildmat.2013.07.097

Wang, J., Liu, E., & Li, L. (2018). Multiscale investigations on hydration mechanisms in seawater OPC paste. *Construction and Building Materials*, *191*, 891–903. https://doi.org/10.1016/j.conbuildmat.2018.10.010

Zuo, J. ping, Hong, Z. jie, Xiong, Z. qiang, Wang, C., & Song, H. qiang. (2018). Influence of different W/C on the performances and hydration progress of dual liquid high water backfilling material. *Construction and Building Materials*, *190*, 910–917. https://doi.org/10.1016/j.conbuildmat.2018.09.146